Fisheries and Oceans Science | Pêches et Océans Sciences

CSAS | **SCÉS**

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Research Document 2000/007 | **Document de recherche 2000/007**

Not to be cited without permission of the authors [1] | Ne pas citer sans autorisation des auteurs [1]

Atlantic salmon (*Salmo salar* L.) stock status on rivers in the Northumberland Strait, Nova Scotia area, in 1999

S. F. O'Neil, K.A. Rutherford, and D. Aitken

Diadromous Fish Division
Science Branch, Maritimes Region
Bedford Institute of Oceanography
P.O.Box 1006
Dartmouth, N.S.
B2Y 4A2

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2000

Canada

Abstract

Fifteen separate rivers on the Northumberland Strait shore of Nova Scotia support Atlantic salmon stocks. Stock status information for 1999 is provided for eight of those stocks based on the conservation requirements and escapements calculated either from a mark-and-recapture experiment (River Philip), capture (exploitation) rates in the angling fishery, or a count of fish by snorkel divers (Sutherlands River). Additional information is included for the three principal rivers in the area, East River, Pictou; River Philip and West River, Antigonish.

Anglers reported harvesting or releasing 580 small salmon (grilse) and 1,160 large salmon on the rivers within the area. First Peoples reported harvesting about 120 fish (large salmon and grilse).

Juvenile salmon densities were found to be high compared with those found on many rivers in the Maritime Provinces. The mean densities of fry and parr on West River, Antigonish, as determined in an electrofishing survey, were greater than 120 fry and about 40 parr per 100 m^2.

The population estimate on River Philip, based on the mark-recapture method, indicated spawners were surplus to the conservation requirement in 1999. On Sutherlands River, snorkel divers counted adult salmon which numbered slightly more than the desired conservation number. On several other rivers in the area, estimated spawner numbers exceeded requirements (East River, Pictou; West, Antigonish; and West, Pictou). The estimated escapements to River John, Waugh River and Wallace River were well below conservation requirements.

Forecasts of salmon returns for 2000 were estimated as the average of the five-year estimates for returns and are provided for East River, Pictou; River Philip and West River, Antigonish. Returns of grilse and large salmon surplus to conservation requirements are forecast for 2000 on all three rivers.

Résumé

Les stocks de saumon atlantique dépendent de quinze rivières de la côte du détroit de Northumberland de la Nouvelle-Écosse. Des renseignements sur l'état des stocks en 1999 sont présentés pour huit de ces stocks en fonction des besoins de conservation et des échappées calculées à partir d'un essai par marquage et recapture (rivière Philip), des taux de captures (exploitation) de la pêche à la ligne ou d'un dénombrement des poissons par les plongeurs avec tuba (rivière Sutherlands). Des renseignements supplémentaires sont donnés pour les trois principales rivières de ce secteur : rivière East, Pictou ; rivière Philip et rivière West, Antigonish.

Les pêcheurs à la ligne ont signalé la récolte ou la remise à l'eau de 580 petits saumons (madeleineaux) et de 1160 gros saumons dans ces rivières. Les Premières nations ont signalé une récolte d'environ 120 poissons (gros saumons et madeleineaux).

Les densités de saumons juvéniles étaient élevées comparativement à celles dans bon nombre d'autres rivières des Maritimes. Les densités moyennes d'alevins et de tacons dans la rivière West, Antigonish, telles que déterminées par un relevé par pêche électrique, dépassaient 120 alevins et environ 40 tacons par 100 m^2.

L'estimation de la population dans la rivière Philip, faite à partir des données de marquage-recapture, indiquait un excédent de géniteurs par rapport aux besoins de conservation pour 1999. Des plongeurs avec tuba ont dénombré les saumons adultes dans la rivière Sutherlands, et la valeur obtenue dépassait légèrement les besoins de conservation. Dans plusieurs autres rivières du secteur, le nombre de géniteurs estimé était supérieur aux besoins (rivière East, Pictou ; rivière West, Antigonish ; et rivière West, Pictou). Les échappées estimées des rivières John, Waugh et Wallace étaient largement inférieures aux besoins de conservation.

Les prévisions des remontées de saumon pour 2000 ont été estimées à partir de la moyenne des estimations des remontées sur cinq ans et sont fournies pour la rivière East, Pictou ; la rivière Philip et la rivière West, Antigonish. On prévoit qu'en 2000 les remontées de madeleineaux et de gros saumons dépasseront les besoins de conservation dans les trois rivières.

Table Of Contents

Abstract i

Résumé ii

Introduction 1

Description of fisheries and fisheries data 1

SPORTFISHERY 1
License stub information 1
Angler diaries 3
NATIVE FOOD FISHERY 4
NON-LICENSED SALMON HARVESTS AND ESTIMATES OF UNREPORTED CATCHES 4

Conservation requirements 4

HABITAT AREA 4
EGG AND ADULT REQUIREMENTS 5

Assessment results and discussion 5

RUN TIMING FROM LICENSE STUB AND ANGLER DIARY DATA 5
JUVENILE SALMON SURVEYS 6
East River, Pictou 6
River Philip 6
Sutherlands River 6
Wallace River 7
West River, Antigonish 7
Other rivers 8
ADULT SALMON POPULATION ESTIMATES AND CATCH RATE 8
River Philip 8
Angling exploitation or catch rate 9
Sutherlands River 10
Escapements on the other Northumberland Strait, Nova Scotia, area rivers 10
Wallace River 10
Waugh River 11
River John 11

Forecasts 12

Management considerations 12

Ecological considerations 13

Acknowledgements 13

References 13

TABLES 15
FIGURES 28

Introduction

The Northumberland Strait shore of mainland Nova Scotia includes the area from the New Brunswick and Nova Scotia border to the Canso Causeway in Antigonish County. Several rivers in the area are known to support Atlantic salmon populations and fifteen rivers contain the major populations along this shore (Fig. 1).

This report summarizes the investigations into the state of the salmon populations in the area and focuses on those rivers where angling occurs as a regular fishery. River Philip and Sutherlands River have been used as indicator rivers for the salmon populations on this coast. Information is provided to show how those data are applied to neighboring rivers to estimate the state of the salmon stocks.

Description of fisheries and fisheries data

The terminology used throughout this document describes Atlantic salmon as follows : grilse, one-sea-winter, 1SW, and small salmon are used synonymously to describe a salmon which is less than 63 cm. in length and is assumed to have spent only one winter at sea before returning to spawn; large salmon, multi-sea-winter salmon, and MSW describe a salmon which has spent at least two winters at sea before returning to spawn for the first time and are fish 63 cm. or more in length. Repeat-spawning salmon are fish which have spawned previously, either as a grilse or large salmon, and are usually greater than 63 cm. in length. Angled fish greater than 63 cm. in length are assumed to be large salmon for the purposes of this report.

Recreational fisheries and Native food fisheries occur in the Northumberland Strait, Nova Scotia, area (North NS).

Sportfishery

The angling season for the North NS area rivers was September 1 to October 31 in 1999. The season has remained the same in this area for the past 13 years (1987 until present). The season and daily bag limits remained at eight and two, one-sea-winter fish, respectively. These bag limits were set for the 1992 angling season and have not varied since. Daily catch-and-release of adult salmon of any size has been restricted to four fish.

Sportfishery data are obtained from angler license stubs which are returned after the close of the season, or angler diaries.

License stub information

Anglers are required by law to return their license stub and to supply catch and effort information by river system by date. Not all anglers return their license stubs so the fishing information has to be extrapolated to estimate total effort and catch. Extrapolation to a total harvest takes into account biases inherent in voluntary surveys. The procedure for estimating the catch and the accuracy of the information has been described previously (O'Neil and Harvie 1993; O'Neil *et al.* 1986). The catch and effort information used for the current assessment represents a smaller sample of the data than in years when assessments were completed later in the winter or the following spring. Consequently the angling data should be considered preliminary. Past experience has provided us with adjustment methods which results in estimates within about 15% of final values.

A total of 2,460 anglers purchased licenses in 1999 and 824 licenses were returned by November 30 (a response rate of 34%).

The estimated sportcatch in 1999 for the rivers in the North NS area was 1,739 salmon and grilse (Table 1). Anglers fished approximately 3,700 rod-days on 12 different rivers in the area. Catches of grilse and salmon were substantially above the recent (1994-98) five-year-mean catches in spite of a reduction in the angler effort in 1999 to 3,700 rod-days from a mean of 4,000 over the 1994-98 period (Table 1). The preliminary grilse catch of about 580 fish is 37% above the 1994-98 mean of 420 fish. Preliminary estimates indicate that anglers caught and released 1,160 large salmon in 1999 as compared with about 880 large salmon, on average, over the 1994-98 period.

River Philip; East River, Pictou; and West River, Antigonish; are the three principle rivers on the Northumberland coast of mainland Nova Scotia. Collectively these rivers accounted for two-thirds (66%) of the area catch of large salmon of over 800 fish. These same three rivers also received the bulk of the angler visits; 61% of the 3,700 rod-days reportedly fished along this coast.

The estimated catch of 439 large salmon and grilse on River Philip was the largest catch reported for the North NS rivers (Table 1). Grilse and large salmon catch increased for the second consecutive year from the low numbers reported in 1997 (Fig. 2). Catch can be influenced by water conditions on these late-run rivers because in some years low water prevents river entry of fish until the angling season is nearly over (O'Neil *et al.* 1997). Anglers kept about 100 of the grilse caught in 1999 as compared with the harvest of 92 grilse, on average, over the 1994-98 period. Grilse catches tend to be lower than large salmon catches on the North NS rivers and on River Philip, less variable from year to year (Fig. 2).

The sportcatch on East River, Pictou, also increased for the second consecutive year. Anglers kept about 20 grilse, released an additional 36, and also released an estimated 217 large salmon (Table 1). Although the catch of large salmon has been lower during the past several years than during the 1980s (Fig. 2), the 1999 catch of 217 large fish is well above the 1994-98 mean of 119 fish.

Anglers caught and released over 180 grilse and 230 large salmon on West River, Antigonish. The trend in catches during the past several years has been similar to the trends on River Philip and East River, Pictou (Fig. 2). Release of about 230 large salmon in 1999 is similar to the five-year average (1994-98) number released of about 200 large fish.

Catches of large salmon on several other North NS rivers in 1999 also increased relative to 1998 (Fig. 2). Grilse catch on River John and Wallace River declined in 1999. The number of large salmon and grilse angled on West River, Pictou, increased in each of the last two years over the recent low in 1997. The return of salmon to West River, Pictou, as indicated by angler success, has increased from few fish (less than 10 per year) in the early 1980s to about 160 fish per year over the 1995-99 period.

Angler effort estimated from license stubs has generally been declining on East River, Pictou, over recent years (Fig. 3). The general effort trend has increased since the early 1980s on River Philip and West River, Antigonish. Angler effort on all three rivers declined in 1999 relative to effort in 1998 in spite of improved catches. Catch-per-unit-effort (CPUE) in fish caught per rodday can also be used to indicate abundance of fish. Recent (during the 1990s) catch-per-effort values on East River, Pictou, have ranged from 0.182 in 1994 to 0.486 in 1999. On River Philip, CPUE has varied less than on East River, Pictou. Values during the 1990s have ranged from 0.228 in 1994 to 0.477 in 1996. Angler visits to West River, Antigonish, have increased from a low of about 100 rod-days in 1984 to a high in 1996 of over 1,000. This increase is coincident with declining access to salmon and closed fisheries along the Atlantic coast of Nova Scotia

which have been affected by declining salmon returns. The CPUE for West River, Antigonish, has ranged from a low of 0.231 in 1994 to a high of 0.808 in 1996 (Fig. 3). Catch-per-unit-effort in 1999 was 0.620.

Angler diaries

Angler diaries are mailed to a select number of anglers each year to monitor catch and effort in greater detail than is available from the license stub. Diary data is not suitable for estimating harvest because of the angler selection process; the more active, interested or successful anglers are sent diaries. In 1999 a total of 49 diaries were mailed and 39 returned. Several anglers returned their diaries and indicated that they did not fish. These responses were included in the estimated response rate.

In the early stages of the diary program in the North NS area, anglers were selected according to the river they were more likely to fish, and fishers from the three principle rivers in the area, the East, Pictou; River Philip; and West, Antigonish; were targeted (R. Jones, pers. comm[1]). The data available from the diaries during those early years indicated that many of the anglers were highly mobile depending on prevailing conditions on the various North NS rivers so they could not be divided into groups according to river. Consequently, anglers who fished on any of the three larger river systems were placed into our pool of anglers from which the interested or more successful ones were selected and mailed diaries. Our correspondence with fishers directed them to return the diary if they did not wish to participate in the program. The first names included in the list each year were those belonging to participants who had correctly completed the diaries the previous year.

Response rates have ranged from a low of 66 % in 1997 and 1998 to a high of 83 % in 1995.

Number and response rates for angler diaries mailed to anglers who direct the majority of their fishing effort to the three principle salmon rivers of North NS, 1995-1999.

Year	Number mailed	Number returned wrong address	Effective number	Voluntary Response		Response to Letter		Total returned	Overall % response
				Number	%	Number	%		
1995	67	2	65	39	60	15	23	54	83
1996	47*	0	47	28	60	10	21	38	81
1997	38	0	38	11	29	14	37	25	66
1998	50	0	50	12	24	21	42	33	66
1999	49	0	49	5	10	34	69	39	80

* includes five St. Mary's diaries.

Catch-per-unit-effort for diary holders is generally higher than it is for license stub holders because of the select nature of the group who complete diaries. However, there are exceptions, such as on West River, Antigonish, in 1999, when diary holders reportedly caught 0.381 fish-per-day but license stub reports pegged the catch rate at 0.451 fish-per-day. The CPUE for diary holders in 1999 was highest for the recent five year period 1995-99 on River Philip, middle of the range on East River, Pictou, and lowest on West River, Antigonish (Table 2). The overall catch for diary holders was low on East River, Pictou, only nine fish reported angled. On River Philip, 73 fish were caught by diary holders, the most reported over the 1995-99 period. Anglers on West River, Antigonish, caught 37 fish, which was similar to the number caught in other years (Table 2).

[1] Ross Jones, Fisheries and Oceans, Diadromous Fish Division, Science Branch, Moncton, N. B.

Native food fishery

First Nation traps were operated to catch salmon on River Philip and East River, Pictou. The trap on River Philip began operating on October 7 and fished until November 29. Quotas in the license included kelt salmon during a spring fishery on many rivers and a large salmon and grilse quota of 90 and 50 fish, respectively (Table 3). The East River, Pictou, trap began operation in early August and was fished until November 12. Members of the Pictou Landing First Nation fished gill nets in Merrigomish Harbour for salmon in September and October. The license agreement for Pictou Landing included 70 large salmon and 30 grilse on East River, Pictou, and small numbers of fish on several other rivers (Table 3). The Native Council of Nova Scotia issues members harvest tags for grilse to be taken on rivers open for angling within Nova Scotia.

Catch reports by the First Nations include 31 fish by Millbrook on River Philip and 12 fish on East River, Pictou, by Pictou Landing. Kelt harvest data and individual fisher data for the rivers in the area were not available prior to preparation of this document.

Non-licensed salmon harvests and estimates of unreported catches

Fisheries and Oceans field staff are asked each year to provide an estimate of Atlantic salmon taken by illegal means, as a by-catch in gear licensed for other species, or removed in licensed gear but not reported. Collectively these catches have formed a substantial number of fish in some years but the data is not always readily available and estimates are usually highly dependent on the field staff in a particular area and their level of involvement in the river or salmon fisheries. Consequently, the data is considered a rough estimate and has not been used to derive total returns figures. Nevertheless, Canada, as a signatory nation to the North Atlantic Salmon Conservation Organization, is annually asked to provide an estimate of those harvests (NASCO 1999). The total number of salmon estimated taken in 1999, by various means, which was either unreported or illegal, was about 500 fish (Table 4).

Although the number of fish harvested by illegal means or unreported from licensed fisheries is uncertain by virtue of the type of fishery and the manner in which data is estimated, the number is substantial when you consider that the entire large salmon harvest for the North NS area through licensed fisheries, including a 5% hook-and-release mortality on fish angled, was about 130 fish.

Reports of catches of salmon which occur outside of licensed fisheries or which are unreported amounted to 91 tonnes in the North American Commission area in 1998 (ICES 1999). Harvest of salmon in licensed fisheries in the same area in 1998 was 151 tonnes.

Conservation requirements

Habitat area

The collective habitat area for the Northumberland Strait, Nova Scotia, area rivers is 5,357,000 m^2 (Table 5). Habitat area has not been measured for most rivers by either of the methods in common use, on-site measurement and aerial photo interpretation. The methods used to estimate habitat area for the rivers along the Northumberland shore have been described by O'Neil *et al.* (1997).

Previous assessment reviews recommended an improvement in estimation of habitat area in the rivers of the North NS area to provide a more comprehensive assessment of habitat than that based on the ratio of a proximate survey to drainage basin size. In 1998, the measurement of

habitat using orthophotos began with the acquisition of the appropriate photos for the Wallace River and River Philip and marking of contours for the purposes of digitizing the data. Orthophotos were also acquired for the South River. Completed habitat area measurements were scheduled for the winter of 2000 but organizational changes may alter that scheduling.

The habitat area of West River, Antigonish, has been partially measured in a proximate survey by staff from the Fisheries and Oceans Antigonish office (C. MacInnis, pers. comm.[2]). Those data are incomplete so were not used to adjust the habitat area estimate for West River, Antigonish, based on watershed area and the ratio of proximate survey to drainage basin size.

Egg and adult requirements

The egg requirements for each river were calculated using the conservation value of 2.4 eggs per m^2 (Anon. 1991a and 1991b), the biological characteristics available for the nearest stock, and the habitat areas (Table 5).

Biological characteristic data for South River were applied to rivers in Antigonish County (Afton, Pomquet, South, Tracadie and West, Antigonish) and the East River, Pictou, data to the other rivers in the area (Table 6). The estimated egg requirements for the North NS rivers range from 45,000 on the Afton River to 2.3 million on River Philip (Table 5).

The spawning requirement estimates for the North NS rivers are based on all eggs coming from large salmon spawners. The available biological data indicates that 95% of grilse are males so grilse requirements are to ensure a 1:1 ratio of males to females in the spawning population.

Fifty percent of the large salmon are female in the data available from the South River (Table 6; Chaput and Jones 1991) and these data applied to the habitat area of West River, Antigonish, result in about 350 large salmon spawners needed to meet requirements. Although River Philip is approximately twice the habitat area, the number of large salmon spawners required, approximately 360, is similar to the number for West River, because of the difference in biological characteristics. Spawner numbers for the other area rivers range from as low as 14 for Afton River to 271 for the East River, Pictou (Table 5).

Assessment results and discussion

Run timing from license stub and angler diary data

The timing of returning fish can be implied from reports of angler catches. The license stub reports indicate that the first grilse kept on the three target rivers (East, Philip or West) was in the week which ended on September 26. The larger grilse harvests occurred during the weeks ending on October 10th and October 31st (Fig. 4). Virtually all of the grilse reported kept by anglers occurred in October.

Diary holders report the date of their catch and effort, usually by pool, within a river system. Much of that data is useful to see how fish aggregate in a river and when they move up the system. Catches reported by diary holders also occurred principally in October (Fig. 5). Although few fish were angled on East River, Pictou, the collective evidence regarding angler success indicates that fish were predominately available in mid- to late- October (Fig. 5). The majority of catch reported by diary holders was caught on River Philip from October 12 to October 26.

---

[2] Charles MacInnis, Fisheries and Oceans, Habitat Management Division, Oceans Sector, Antigonish, N.S.

These data are consistent with run timing on these rivers as evidenced by returns to the trap on River Philip when it was operated in the 1950s (Edwards 1958).

Juvenile salmon surveys

Juvenile salmon densities are calculated as the number of fish per $100m^2$. The area measure "$100m^2$" is considered a unit of habitat for the purposes of this paper. Spot-checks are expressed as the number of fish captured during 300 seconds fishing on the electrofishing timer.

East River, Pictou

The density of fry on two sites on East River, Pictou, in 1999, was similar to numbers noted in recent years and well within the range of densities noted for fry at the two sites (Table 7). Parr numbers were down in 1999 for the second consecutive year from the densities recorded in 1997. The average age 1+ and older parr density in 1999 was approximately 11 fish per unit of habitat and below the 39 total parr per unit estimated by Elson as optimal (Fig. 6; Elson 1967).

River Philip

Members of the local river association and the Atlantic Salmon Federation expressed an interest in obtaining additional juvenile salmon data on River Philip because the river is used as an indicator river for rivers in the North NS area. In 1999 an additional density site was selected on River Philip on the Black River tributary in that system (Fig. 7). The fry and parr (age 1+ and 2+) densities at the new site (site 7) were 48 and 9 fish, respectively (Table 7). Parr numbers in 1999 at the other two sites fished were lower than those observed during previous electrofishing surveys. Fry numbers at those same sites were the highest seen in a limited series of electrofishing results. Fry densities of over 100 per $100m^2$ are high relative to Elson's "norm" of 29 fish per unit of habitat (Elson 1967). The average age 1+ and older parr density for the two sites fished more than one consecutive year was 34 fish per $100m^2$ and higher than the average densities for the East River, Pictou, and Wallace River (Fig. 6). A spot-check on the West Branch, River Philip, indicated small numbers of salmon were present (Table 8). Brown trout were more numerous than salmon at the spot-check site.

Sutherlands River

The number of age 0+ parr captured during five minutes of fishing on Sutherlands River on the upriver site (site 3, Table 8; 59 fish) was similar to numbers found in other years which ranged from 42 to 100 fish. The number of age 1+ and older parr found, seven fish, at the same site, was lower than the numbers observed previously. On the lower river site (site 1), fry and parr numbers were similar to numbers found in other years. The low number of age 1+ or older parr found at the upper site may be partly as a result of the low water at the site when the electrofishing was conducted.

Parks Falls limits the upstream migration of Atlantic salmon on the system. The electrofishing crew spent several minutes fishing a section of the river above the falls in 1999 (indicated as site two in Table 8) but failed to find any juveniles. Previous visits to the area in 1992 and 1995 also failed to find any Atlantic salmon young.

A high proportion of the fry and parr captured by electrofishing were observed to be infested with leeches. The incidence of leech infestation was not determined but evidence of a high rate of

infestation was noted in each of the years electrofishing was conducted, at least since 1994. Parr were also noted to be infested with leeches during the autumn snorkel-diver surveys of adult salmon on November 3, 1999.

Wallace River

Adult spawner and juvenile numbers have varied annually to a considerable degree on the Wallace River. As a result, the semi-annual electrofishing visits to the river became annual beginning in 1995. Several sites were visited for five-minute spot-checks and two density sites were fished beginning in 1996. Fry (age 0+ parr) and parr (age 1+ and 2+) numbers caught during five minutes of fishing (spot-checks) indicate a lack of consistency in juvenile numbers regardless of site (Table 8). Number of fish per 100 square meters at the two density sites were likewise variable (Table 7). Fry numbers ranged from zero in 1999 and 1998 to 110 fish per $100m^2$ in 1997at one site (Site 7). Total parr numbers at this site ranged from approximately 10 in 1999 to over 21 in 1998. In 1999, one site (site 6) which had become unstable because of windfalls and bedload movement, was relocated upstream about two kilometers and given a new site number (site 8). The density of fry and parr at the new site was 82 and 15 fish per $100m^2$, respectively.

Although the juvenile densities on the Wallace River are lower than the numbers found on several other North NS streams (Fig. 6), they are higher than the density of parr found on rivers along the Atlantic coast of Nova Scotia, such as the St. Mary's River (O'Neil *et al.* 1998). Production of parr at Elson's "norms" would be near 39 total parr per 100 m^2, which is higher than the parr density at the two sites on the Wallace (Elson 1967).

West River, Antigonish

High juvenile Atlantic salmon numbers on two sites on West River, Antigonish, were not believed to be sustainable throughout the system so beginning in 1996, additional sites were electrofished to provide a broader picture of the juvenile numbers in the system. The sites chosen were selected based on two criteria: relationship to previous data, if available; and, they were to be located in areas of the system not represented by the two regularly fished sites. The additional sites selected were two on the Ohio River, one in the lower end where gradient is low, and one well up the Ohio system where the gradient was greater. The third additional site was located on the main branch of the West River, Antigonish, below the forks where the Ohio, James and Beaver rivers come together. The lower Ohio River site and main West site were sites previously fished in 1978 and described in Cameron and Gray (1979).

The density of fry and parr remain at high levels on the Beaver and James rivers in the West River, Antigonish, system (Fig. 8; Table 7). The number of fry per square meter has exceeded 100 for each of the years the sites have been fished in the 1990s on both tributaries. In contrast, in 1978, the density of fry at the James river site was approximately 25 fish per $100m^2$. Parr numbers are also high relative to the Elson estimate of optimal carrying capacity for habitat of 39 total parr per $100m^2$ (Elson 1967). Beaver and James river total parr densities have remained over 50 fish per $100m^2$ throughout the 1990s and in 1999 were 83 and 62 fish per $100m^2$. Densities at the other three sites visited reduced the average parr density for the system to about 39 parr per unit of habitat (Table 7; Fig. 6). Average fry densities in 1999, 126 fish per unit, remained high relative to the Elson "norm" of 29 age 0+ parr per unit of habitat.

Juvenile salmon sizes and condition factors could be used to examine the effect that such high densities has on growth. Length and weight data were collected on fish at several locations for three or more rivers in the North NS area but the analysis has not been completed.

Other rivers

Spot-checks were completed on French River, Pictou; Barney's; South; Pomquet; and the Afton rivers (Table 8), in addition to the rivers already discussed. The electrofishing site visits were scheduled to occur in September, when temperatures had begun to cool, to obtain information on fish sizes which would coincide with the end of a typical growing season. On French River, Pictou, the fry and parr numbers were within values noted previously. On the remaining systems, numbers of fry and parr were lower on several sites than in previous years. These data may indicate lower spawner success or decreased survival in some locations. Future and more comprehensive monitoring would be required to determine if these sparse spot-checks indicate low juvenile numbers.

On Barney's River, a main stem site (site 1) was electrofished which was located downstream of an aquaculture site for salmon, which was under construction. Future visits to this site may serve to indicate the presence of escaped aquaculture fish or if the river environment is affected by the effluent from the facility.

Adult salmon population estimates and catch rate

River Philip

In 1999, an attempt was made to have anglers participate in a mark-and-recapture population estimate on River Philip. A similar procedure was successful previously on the Musquodoboit River (O'Neil *et al.* 1998). A seining exercise was scheduled for the river to apply marks for a separate study which would require snorkel-divers conducting a survey of the river. The Cumberland County Rivers Association agreed to assist in the application of marks to angled and released large salmon. The objective was to later examine fish captured in the seine for marks and thus eliminate the need for the snorkel-diver survey if sufficient fish could be marked and recaptured by seining. Collectively the eight anglers who participated in the program captured, marked (hole punch in lower lobe of caudal fin) and released 25 large salmon. Seining for salmon took place on October 28th and a total of 15 fish were captured and examined for marks, none of which bore angler-applied hole punches.

Atlantic salmon were seined on River Philip on October 28th to mark fish for use in the mark-and-recapture population estimate. Since angler marks were not present on the fish, 13 of the 15 large salmon captured by seining were tagged with yellow disk tags and released; two fish were taken to the Cobequid Fish Culture Station for broodstock for the Fish Friends program. Only large salmon were tagged because the angling season was not over and we were concerned that tagged grilse might be removed from the pool of tagged fish. The tagging procedure consisted of holding fish in a measuring trough while two disks 1.3cm in diameter were attached to the dorsal fin of the fish near the musculature of the back. Tags were applied with plastic holdfasts which were serrated and could be cinched tight to the sides of the fin. The yellow disks were known from previous experience to be highly visible and easily seen by snorkel-divers conducting river surveys (swim-throughs).

Fish were captured at several locations and none were marked below Spencer's Bridge (Fig. 7; Table 9a). Snorkel-divers swam the river four days later to count fish and record those with and without tags. A four-day interval was used to ensure fish had an opportunity to recover from the tagging and mix with unmarked fish. The water levels at the time of tagging and during the four-day interval were sufficient to permit fish movement. In other words, fish were not confined to pools because of low water levels and could move at will. The river was divided into five sections and a team of two divers swam each section (Fig. 7). The river was not surveyed below Spencer's Bridge because of low visibility. It was assumed that marked fish remained or returned

to the area of the river above Spencer's or proportionate numbers of marked and unmarked fish moved out of the section surveyed by divers in order to meet the assumptions of a mark-and-recapture experiment (Ricker 1975).

Snorkel divers observed seven tagged fish among the 172 large salmon and 71 grilse counted (Table 9a). The Bayesian post-fishery population estimate for the area of the river above Spencer's Bridge, for large salmon, was 320 fish (5^{th} and 95^{th} percentiles 200 - 830; Fig. 9; *loc. cit.* Gazey and Staley 1986). The ratio of grilse to large salmon noted during the swim-through was used to estimate the total number of grilse in the area above Spencer's to be 132 fish (Table 9b). The watershed area above Spencer's represents 63.25% of the drainage basin so an entire river population estimate was calculated by extrapolating to the entire river watershed[3]. The post-fishery total river population estimate was 715 large salmon and grilse.

Pre-fishery population sizes can be estimated by summing the post-fishery figures and estimated removals in the fisheries. The pre-fishery salmon population on River Philip in 1999 was 864 fish; 538 large salmon and 326 grilse (Table 9b and 10).

Escapement to the river can be defined as fish which escaped capture and were available to spawn. The escapement to River Philip in 1999 was 506 large salmon and 209 grilse. Conservation requirements for the river are 358 salmon and 75 grilse so spawner numbers were surplus to requirements in 1999; over 140 large salmon surplus and over 130 grilse (Table 10).

Angling exploitation or catch rate

The sportcatch on River Philip was 439 fish. Expressed as a percentage of the river returns, after removing the First Nation harvest in the estuary, anglers caught 53% of the fish (Table 9b). The catch rate for large salmon was 0.56 and for grilse 0.47 (Table 9b and 10).

Catch rates on the river have been highly variable. Catch rates for large fish during the past four years (the years where separate population estimates for large salmon have been determined) varied from 16% in 1997 to 70% in 1998. The grilse catch rates have also been variable but less so than for large fish. They have ranged from 27 to 87% over the past four years.

	River Philip catch rates	
Year	Large salmon	Grilse
1996	0.60	0.87
1997	0.16	0.27
1998	0.70	0.72
1999	0.56	0.47

The low catch rate for large salmon and grilse estimated for 1997 is well outside the range of the catch rates for the other three years. Angler effort, as reported on license stubs, and catch-per-unit effort, exhibited a sharp contrast in 1997 to the same two measures for other years (Fig. 3). Angler effort on River Philip in 1997 was only 55% of the long-term (1984-99) average effort on the river. CPUE, on the other hand, was 68% of the mean for the same period. East River, Pictou; and West River, Antigonish, exhibited the same relatively low effort but CPUE values more typical of other years (Fig. 3).

[3] Nova Scotia Land Registration and Information Service, Halifax, Nova Scotia, maps and drainage basin sizes for each tributary were used to quantify the area of the river above and below Spencer's Bridge.

Sutherlands River

Snorkel-divers have surveyed Sutherlands River five consecutive years, 1995-99. A survey crew of two snorkel-divers with a person acting as shore support have covered the river from Parks Falls, the uppermost limit of salmon access, to tide head. Counts during the five years have all occurred between November 3rd and the 17th (Table 11).

The conservation requirement for Sutherlands River is relatively small, 25 large salmon and five grilse, because only four kilometers of river are accessible to salmon. The biological characteristics for the stock are borrowed from the salmon stock on East River, Pictou (Table 6). Escapement to the river in each of the five years that the river has been surveyed have approximately met (1995) or exceeded (1996-99) conservation requirements (Table 11).

Anglers seldom report fishing on the river so angling data is not a valid tool for estimating catch rates for application to neighboring rivers. Pictou Landing First Nation fishes in Merrigomish Harbour where the Sutherlands; Barney's; and French, Pictou; rivers discharge. The license for the band includes 40 large salmon for the harbour area. Escapements to Sutherlands River, on average, have achieved 135 and 408% of the large salmon and grilse requirements, respectively (Table 11). Juvenile numbers and the Sutherlands River adult salmon survey data indicate that spawning requirements have been met on all three of these Merrigomish Harbour rivers.

Escapements on the other Northumberland Strait, Nova Scotia, area rivers

The catch rate estimated from the River Philip mark-and-recapture data and angling catch information was applied to the sportcatch estimates for the other North NS rivers to estimate salmon returns. Escapement estimates were calculated by subtracting removals from the returns figures for each river. Removal estimates included an assumed loss through a 5% hook-and-release mortality of released fish. Surplus and deficit estimates were obtained by subtracting conservation requirements from escapements (Table 10). Estimates of escapements were not possible for all area rivers: anglers did not fish all rivers in the area; or, they did not report sufficient catch on all rivers fished, to permit an estimate of escapement.

Escapement estimates for 1999 were derived for East River, Pictou; River John; Wallace River; Waugh River; West River, Antigonish; and West River, Pictou. Large salmon deficits were evident from the procedure on River John, Wallace River, and the Waugh River (Table 10). Surplus numbers of fish occurred on East River, Pictou; River Philip; Sutherlands River (marginal); West River, Antigonish; and West River, Pictou.

Wallace River

Wallace River return estimates have been below conservation requirements for three of the past four years (refer to text table). Returns to the Wallace River in 1998 were estimated to be well below requirements. The fry densities in 1999 at the two density sites were zero fish and 82 fish per $100m^2$. The zero density is not exceptional as no fry were found at that site on previous occasions and the 82 fry per unit is well above the Elson "norm" of 29 (Table 7). The number of fry noted on four spot-check sites is not conclusive with respect to escapements in 1998. These data support the need for a more thorough examination of the return and escapement estimates on the Wallace River.

Wallace River returns relative to requirements, 1996-1999. Requirements: 232 Large salmon and 49 grilse						
Year	Revised River Philip catch rates[1]		Wallace River returns based on catch rates and angling data		Surplus or deficit based on requirements and returns	
	Large salmon	Grilse	Large salmon	Grilse	Large salmon	Grilse
1996	0.60	0.87	150.00	28.80	-82.00	-20.20
1997	0.16	0.27	663.89	147.08	431.89	98.08
1998	0.70	0.72	86.25	57.13	-145.75	8.13
1999	0.56	0.47	179.47	47.05	-52.53	-1.95

1 Original catch rates published in assessments were calculated based on preliminary catch statistics. These catch rates have been revised to reflect the final catch estimates except for 1999 which is preliminary.

The habitat of the Wallace River is considerably different on the main river and the West Wallace. The main river consists of riffle and pool habitat over a clean cobble substrate. Much of the West Wallace is relatively low gradient with sandy substrate. Spawning requirements may have to be adjusted for the river to reflect the habitat, if and when a habitat survey is completed.

Waugh River

Little is known about the Waugh River. Some First Nation fishery occurs but on a sporadic basis. Harvest reports are nil but some fish are taken by angling or other means. Anglers do not regularly visit the river so angling data is of little value in some years in estimating returns. Data have not been collected on juveniles. A survey of juveniles is recommended to better understand the status of the salmon population on the river.

River John

Recreational fishers and Aboriginals remove salmon from River John. Pictou Landing Band members take salmon by a variety of means but netting on River John is not a method permitted under their communal license. First Nation harvest reports are limited and in most years a nil catch report is filed for this river. Estimates of unreported harvest on River John typically are high when compared with the angling catch. In 1999, Fisheries and Oceans field staff estimated 50 fish (predominately large salmon) were taken (Table 4). Angler catch estimates included catch and release of 60 large salmon.

River John is a relatively small river, the fifth largest in the North NS area, and habitat area is estimated at less than one-half of that for River Philip. Angler catch is typically 60 to 80 fish per year (Table 1) and Aboriginals take some fish. Returns to the river have been below requirements in two of the past four years, 1998 and 1999. Catch-per-unit-effort for anglers has been highly variable (ranges from 0.089 to 0.581) but in years where escapement was estimated below requirements, CPUE's were relatively high.

Year	1984	1985	1986	1987	1988	1989	1990	1991
CPUE	0.104	0.263	0.581	0.219	0.173	0.194	0.172	0.331
Year	1992	1993	1994	1995	1996	1997	1998	1999
CPUE	0.275	0.170	0.173	0.089	0.272	0.334	0.306	0.324

These data support the need for a closer examination of the stock status if directed fisheries continue on the river. The available stock status indicators are not consistent and conflict with evidence from nearby rivers such as River Philip and East River, Pictou.

Forecasts

The five-year average is the only available forecast for rivers in the North NS area. Forecasts are provided for East River, Pictou; River Philip; and West River, Antigonish; using the return and escapement information previously described. A forecast return to Sutherlands River is also provided based on the average escapement over the last five years. This latter forecast would be an underestimate of returns because the available data are not sufficient to reconstruct river returns. First Nation harvest of the Sutherlands River stock has been estimated at a minimum of 13 fish per year.

The return forecast for East River, Pictou, in 2000, is 378 (90% C.L. ±173) large salmon, and 114 (90% C.L. ±28) grilse. This represents 139% of the requirement for large fish and 200% of the requirement for grilse (Table 12; Fig. 10).

Returns in 2000 on River Philip are forecast to be 635 (90% C.L. ±256) large salmon, and 301 (90% C.L. ±156) grilse. Returns are forecast to exceed conservation requirements by 117% and 401% for large salmon and grilse, respectively.

On West River, Antigonish, returns are also forecast to be surplus to requirements by 140% for large salmon. Estimated return numbers in 2000 will be 494 (90% C.L. ± 205) large salmon. The grilse forecast for 2000 is 315 (90% C.L. ± 136) fish (Table 12; Fig. 10).

The average escapement to Sutherlands River over the past five years has been 34 large salmon and 20 grilse; 138% and 408% of the conservation requirements, respectively (Table 11). Assuming the five-year average number of fish will return (escape) in 2000, a surplus number of spawners will be available for harvest. These estimates are known to be underestimates because the harvest of a minimum of 13 fish per year by First Nations has not been incorporated into the returns.

Management considerations

Field staff reports of removals which occurred by illegal means or legitimate removals which have not been reported through conventional channels has become a large portion of the harvest on this shore. Almost 500 fish were reported taken in 1999 (Table 3). Accurate scientific advice can only be provided if the information available is reliable and accurate. The current North America-wide decrease in salmon stock levels has increased the importance of limiting illegal harvest and non-reporting. Development of a program to gain improved control over these practices is strongly recommended.

Habitat assessments on the rivers in the North NS area can and should be improved upon.

Return estimates on River John and Wallace River are inconsistent in many respects with neighboring rivers and within the data available on these rivers. It is recommended that additional investigations into various aspects of these two rivers including habitat, return estimates, a broader picture of the juvenile densities, and a better estimate of harvests (legitimate or otherwise) be undertaken.

Biological characteristic data should be obtained for River Philip and West River, Antigonish. A program to obtain similar data on the other area rivers should be developed.

Ecological considerations

Water levels and temperatures can affect parr survival or river entry of adult salmon (Amiro *et al.* 1998). Temperatures were warm on North NS rivers in 1999 and water levels low relative to other years (C. MacInnis[4], pers. comm.; unpublished data). The discharge data for Middle River, Pictou, at Rocklin, can be referred to as a general indicator of water levels in the area because it is located approximately in the middle of the North NS assessment area (Fig. 1). In 1999, as in 1998, discharge on Middle River was highly variable throughout the September and October period (Fig. 11). Daily discharge in 1999 ranged from a low of less than 1 m^3 per second to over 10 m^3 per second. Generally, water levels were above the recent 1993-97 mean levels and with a couple of short-term exceptions, above discharge levels in 1998 (Fig. 11). Temperature monitors were deployed at several sites on West River, Antigonish, in 1999. Data from two of those sites, James and Beaver river, indicate daily temperatures rarely exceeded 23°C and when they did so, it was for short intervals (Fig. 12).

Acknowledgements

Several individuals in the organizations in the area assisted with various aspects of the work. The assistance of members of the Cumberland County River Enhancement Association, and in particular, Dan and Jack Ripley, were instrumental in our completion of the assessment work. The Pictou County Rivers Association assisted in the electrofishing and broodstock collections. Mr. Bob Ferguson helped in the organization of those activities and in the field work; Bill Cardiff also participated in the electrofishing. The West River, Antigonish, temperature data was provided by Charles MacInnis who also aided our river work by providing up-to-date information on water levels and local habitat conditions. Lewis Hinks of the Atlantic Salmon Federation participated in the planning for the River Philip mark-and-recapture and the tagging activities. Sonya Melnyk helped with the electrofishing on several rivers.

Deborah Stewart managed the angler diary and license stub programs and summarized the data.

References

Anon. 1991a. Definition of conservation for Atlantic salmon. CAFSAC Advisory Doc. 91/15. 4p.

Anon. 1991b. Quantification of conservation for Atlantic salmon. CAFSAC Advisory Doc. 91/16. 15p.

Amiro, P.G., C.J. Harvie, S. F. O'Neil, and T.L. Marshall. 1998. Analyses of trends in returns of Atlantic salmon (*Salmo salar*) to rivers in Nova Scotia and Bay of Fundy, New Brunswick, and status of 1997 returns relative to forecasts. Can. Stock Assessment Secretariat Res. Doc. 98/46.26p.

Cameron, J.D. and R. W. Gray. 1979. Estimated densities of juvenile Atlantic salmon and other freshwater fishes in selected Nova Scotia streams, 1978. Can. Data Rep. Fish. Aquat. Sci. No. 163. 43p.

Chaput, G. and R. Jones. 1991. Evaluating spawning requirements, returns, escapements and surpluses to conservation levels of Atlantic salmon for selected Gulf Nova Scotia rivers. CAFSAC Res. Doc. 91/73. 23p.

---

[4] Charles MacInnis, Fisheries and Oceans, Habitat Management Division, Oceans Sector, Antigonish, N.S.

Chaput, G. and R. Jones. 1994. Mainland Gulf Nova Scotia Atlantic salmon (*Salmo salar*) stock status. DFO Atlantic Fisheries Res. Doc. 94/8. 49p

Claytor, R.R., R. Jones, P. LeBlanc, and G. Chaput. 1995. Mainland Gulf Nova Scotia Atlantic salmon (*Salmo salar*) stock status, 1994. DFO Atlantic Fisheries Res. Doc. 95/15. 33p.

Edwards, H.E. 1958. Observations at River Philip 1958: Early-run experiment, 1958. Unpublished manuscript, Fisheries and Oceans (formerly Department of Fisheries) Fish Culture Branch, Saint John, N.B. 25p.

Elson, P.F. 1967. Effects on wild young salmon of spraying DDT over New Brunswick forests. J. Fish. Res. Bd. Can. 24(4). 37p.

Gazey, W.J. and M.J. Staley. 1986. Population estimation from mark-recapture experiments using a sequential Bayes algorithm. Ecology. 67(4):941-951.

ICES 1999. North Atlantic Salmon Stocks. Extract of the report of the Advisory Committee on Fishery Management to the North Atlantic Salmon Conservation Organization. Report No. 7. International Council for the Exploration of the Sea, No. 7, May 1999. 44p.

NASCO (North Atlantic Salmon Conservation Organization). 1999. Report on the activities of the North Atlantic Salmon Conservation Organzation, 1998-1999. NASCO, 1999.

O'Neil, S.F., M. Bernard, and J. Singer. 1986. 1985 Atlantic salmon sport catch statistics, Maritime Provinces. Can. Data Rept. Fish. Aquat. Sci. No. 600. 71p.

O'Neil, S.F. and C.J. Harvie. 1993. Evaluation of the precision of catch data in the Nova Scotia Atlantic salmon catch-effort card system and feasibility of a New Brunswick application. CAFSAC Res. Doc. 93/31. 34p.

O'Neil, S.F., D. A. Longard and C.J. Harvie. 1996. Stock status of Atlantic salmon on the Northumberland Strait, Nova Scotia, area rivers in 1995. DFO Atlantic Fisheries Res. Doc. 96/127. 45p.

O'Neil, S.F., C.J. Harvie, D.A. Longard, and P.G. Amiro. 1998. Stock status of Atlantic salmon (*Salmo salar* L.) on the Eastern Shore of Nova Scotia, Salmon Fishing Area 20, in 1997. Canadian Stock Assessment Secretariat Res. Doc. 98/37. 64p.

O'Neil, S.F., D.A. Longard and C.J. Harvie. 1997. Atlantic salmon (*Salmo salar* L.) stock status on rivers in the Northumberland Strait, Nova Scotia, area in 1996. DFO Can. Stock Assessment Secretariat Res. Doc. 97/22. 45p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada No. 191. 382p.

Table 1. Atlantic salmon sportcatch and effort for rivers in the Northumberland Strait area of mainland Nova Scotia, 1999, 1998, and mean catches, 1994-98.

	1999 Preliminary				1998				1994-98 means							
	Grilse		Salmon		Grilse		Salmon		Grilse				Salmon		Effort	
River	retained	released	released	Effort	retained	released	released	Effort	retained	95% C.I.	released	95% C.I.	released	95% C.I.	rodday s	95% C.I.
Barney's	0	0	9	9	0	0	1	23	2	5.4	0	1.1	3	4.8	24	22.9
East, Pictou	22	36	217	566	28	25	118	698	24	9.2	20	15.5	119	112.6	592	216.9
French, Colchester	0	0	0	7	1	0	1	20	1	0.7	0	0.0	4	8.6	21	17.4
French, Pictou					0	0	0	4	1	N/A	1	N/A	5	N/A	8	N/A
Middle, Pictou									0	N/A	0	N/A	0	N/A	0	N/A
Pomquet	2	4	2	13	0	1	4	45	0	N/A	1	N/A	2	N/A	0	N/A
Pugwash									0	N/A	0	N/A	0	N/A	0	N/A
River John	18	4	60	237	20	27	41	214	18	8.1	9	14.0	55	49.4	193	66.0
River Philip	101	45	293	1048	84	29	240	1286	92	58.6	33	30.2	283	270.7	1284	549.6
Shinimikas									0	N/A	0	N/A	0	N/A	1	N/A
South	16	16	43	99	3	7	9	74	4	4.6	6	6.7	9	10.3	70	35.6
Sutherlands									0	N/A	0	N/A	0	N/A	5	N/A
Tidnish									0	N/A	0	N/A	0	N/A	0	N/A
Tracadie (Monastery)									0	N/A	0	N/A	0	N/A	0	N/A
Wallace	11	11	101	381	29	12	60	348	18	8.8	13	9.9	68	39.0	469	119.1
Waugh	13	7	27	163	17	16	49	267	14	8.6	9	5.4	53	57.2	232	166.3
West, Antigonish	81	105	231	672	64	69	180	895	55	43.2	63	81.4	203	193.1	706	371.9
West, Pictou	40	43	181	528	32	7	109	528	25	27.2	11	14.0	78	91.6	437	283.3
Wright	0	0	0	4					1	N/A	1	N/A	0	N/A	11	N/A
Totals	304	271	1164	3727	278	193	812	4402	254		167		882		4052	

Table 2. Number of effective diaries, catch, effort and catch-per-unit effort (CPUE) for diary holders on three north Nova Scotia rivers in 1995-1999.

River	Diary holders that fished	Catch				Effort		CPUE	
		Grilse		Salmon					
		Retained	Released	released	Total	Hours	Rod days	Per hour	Per rod day
1995									
East River, Pictou	10	0	0	10	10	271	59	0.037	0.169
River Philip	15	23	1	46	70	839	185	0.083	0.378
West River, Antigonish	13	8	6	16	30	254	65	0.118	0.462
Total	38	31	7	72	110	1364	309		
1996									
East River, Pictou	9	4	2	26	32	342	62	0.094	0.516
River Philip	15	14	2	49	65	761	169	0.085	0.385
West River, Antigonish	14	12	19	47	78	331	77	0.236	1.013
Total	38	30	23	122	175	1433	308		
1997									
East River, Pictou	8	2	5	20	27	238	50	0.114	0.540
River Philip	14	14	1	24	39	620	134	0.063	0.291
West River, Antigonish	9	3	3	16	22	88	26	0.251	0.846
Total	31	19	9	60	88	945	210		
1998									
East River, Pictou	6	2	6	7	15	314	57	0.048	0.263
River Philip	22	12	4	28	44	1142	228	0.039	0.193
West River, Antigonish	10	8	7	29	44	223	64	0.197	0.688
Total	38	22	17	64	103	1680	349		
1999									
East River, Pictou	6	1	2	6	9	83	23	0.109	0.391
River Philip	14	16	11	46	73	690	168	0.106	0.435
West River, Antigonish	12	9	10	18	37	299	97	0.124	0.381
Total	32	26	23	70	119	1072	288		

Table 3. First Nation Atlantic salmon harvest allocations and reported harvests in the Northumberland Strait, Nova Scotia, area in 1999.

First Nation	River/area	Harvest plan or license allocation 1SW	MSW	Reported harvest 1SW	MSW
Afton	No license issued for salmon in 1999				
Indian Brook	River Philip (kelt)	10	40		
	Wallace (kelt)	5	20		
	Waugh (kelt)	5	20		
Millbrook	French, Colchester	10			
	Margaree	10	10		
	River Philip - spring	[a]	[a]	14	17
	- fall	90	50		
	Pugwash	10	10		
	Shinimicas	10			
	Wallace - spring	[a]	[a]		
	- fall	0	20		
	Waugh - spring	[a]	[a]		
	- fall	20	0		
	West, Antigonish	10	10		
	West, Pictou	20			
Pictou Landing	East, Pictou[a]	30	70		12
	Merigomish Hbr.	10	30	40 mixed size	
	River John	20	10		
	West, Pictou	25	37		
Native Council	SFA 18	1820[b]			

[a] Kelt fishery provisions in the license permitted catch per community needs.

b Tags available for issue but not necessarily issued.

Table 4. Estimates of Atlantic salmon catches which have occurred on the Northumberland Strait shore of mainland Nova Scotia but have not been reported as catches in licensed fisheries. These data provided by Fisheries and Oceans field staff who have estimated the numbers from a variety of means.

River or coastal area	Estimated number of fish[1]
Afton	15
Barney's	30
East, Pictou	40
French, Colchester	25
French, Pictou	15
Pomquet	15
Pugwash	28
Rights	2
River John	50
Philip	80
Shinimicas	40
South	15
Sutherlands	15
Tidnish	1
Tracadie / Monastery	20
West, Antigonish	25
Wallace	40
Waughs	20
West, Pictou	20
Total	496

1 Salmon were mixed size, large and small, but field staff estimated that they were about 80% large based on available reports.

Table 5. The drainage basin areas, habitat areas, egg requirements and spawner requirements for the Northumberland Strait, Nova Scotia, area rivers (from O'Neil *et al*. 1997).

River	Drainage basin area ($m^2 \times 10^2$)	Reference river for area estimate	Habitat area [1] ($m^2 \times 10^2$)	Egg requirements @240 eggs/100 m^2 (in 1000s of eggs)	Spawner requirements [2]	
					Grilse	Salmon
Afton River	432,526	South	189	45	0	14
Barney's River	1,564,104	Philip	2,128	511	17	79
East River, Pictou	5,359,716	Philip	7,291	1,750	57	271
French, Colchest	2,060,853	Philip	2,804	673	22	104
French River, Pic	1,278,680	Philip	1,740	417	14	65
Middle River, Pict	2,170,644	Philip	2,953	709	23	110
Pomquet River	1,756,531	South	769	185	1	57
Pugwash River	1,815,574	Philip	2,470	593	19	92
River John	2,920,443	Philip	3,973	954	31	148
River Philip	7,259,707	Philip	9,621	2,309	75	358
South River	2,170,158	South	950	228	0	70
Sutherlands River [3]			666	160	5	25
Tracadie (Monast	1,202,519	South	526	126	1	39
Wallace River	4,578,838	Philip	6,229	1,495	49	232
Waugh River	2,301,964	Philip	3,132	752	25	116
West River, Antig	3,530,382	Philip	4,803	1,153	1	353
West River, Picto	2,445,182	Philip	3,326	798	26	124
Totals			53,570	12,857	365	2255

[1] The habitat area:drainage basin area ratio used to calculate habitat areas where measurements were not available were: for River Philip: 0.0013604 and for South River: 0.00043776.

[2] Spawner requirements based on biological characteristics from East River, Pictou, except for the Afton, Pomquet, South and Tracadie rivers which have spawner requirements based on data from South River.

[3] Area below falls, from Chaput and Jones 1994.

Table 6. Estimation of spawner requirements for East River, Pictou and South River (adapted from Claytor et. al. 1995).

EAST RIVER PICTOU

Habitat area (sq.m.)				729,125	
Optimal egg deposition (2.4 eggs/sq.m.)				2.4	
Total egg requirements				1,749,900	
Biological characteristics					
Fecundity				1,764	eggs/kg
Small salmon	% female			5	
	mean wt. (kg)			1.7	
Large salmon	% female			60	
	mean wt. (kg)			6.1	
Eggs per small salmon spawner		=	eggs/kg * mean wt(kg) * % female		
		=	1764 * 1.7 * 5%		
		=	150		
Eggs per large salmon spawner		=	1764 * 6.1 * 60%		
		=	6,456		
Required number of large salmon		=	271	—>>	163 female
					108 male
Deficit males		=	54		
Small spawners to obtain deficit males		=	54 / 0.95		
		=	57		
Spawning requirements:		Large	271		
		Small	57		

SOUTH RIVER

Habitat area (sq.m.)				95,000	
Optimal egg deposition (2.4 eggs/sq.m.)				2.4	
Total egg requirements				228,000	
Biological characteristics					
Fecundity				1,764	eggs/kg
Small salmon	% female			3	
	mean wt. (kg)			1.3	
Large salmon	% female			50	
	mean wt. (kg)			3.7	
Eggs per small salmon spawner		=	eggs/kg * mean wt(kg) * % female		
		=	1764 * 1.3 * 3%		
		=	69		
Eggs per large salmon spawner		=	1764 * 3.7 * 50%		
		=	3,263		
Required number of large salmon		=	70	—>>	35 female
					35 male
Deficit males		=	0		
Spawning requirements:		Large	70		
		Small	0		

Table 7. Densities (multiple sweep removal or mark-recapture)of juvenile Atlantic salmon electrofished on rivers in the Northumberland Strait,Nova Scotia area, during some years from 1978 to 1999. Data for 1978 from Cameron and Gray (1978) and for 1991 to 1994 from Claytor *et al.* (1995) and Chaput and Jones (1994).

		Fry per 100 m^2										Parr per 100 m^2									
River	Site	1978	1991	1992	1993	1994	1995	1996	1997	1998	1999	1978	1991	1992	1993	1994	1995	1996	1997	1998	1999
River Philip	1				0.0		*		48.1	0.0	109.8				36.0		53.5		60.2	33.4	14.2
	3									62.6	304.5									142	54.4
	7										48.1										9.3
Wallace	3**	56.9										7.9									
	6***	65.3						86.1	59.9	48.2		20.4						10.4	11.8	8.9	
	7							5.9	110.2	0.0	0.0							17.8	11.9	21.2	9.6
	8[a]										81.9										15.3
East R. Pictou	3	58.1		116.8		34.0	104.8		106.6	19.8	46.2	37.6		30.1		27.0	28.3		36.0	19.4	4.6
	4			342.5	64.0	169.0	123.6		333.7	94.5	173.9			84.0		34.0	40.6		40.6	34.5	17.1
	7																				
French	1	34.9										7.6									
	2	3.5										11.6									
	3	41.7		90.8		120.0						8.4		15.6		40.0					
Barneys	3			97.8		151.0								32.9		20.0					
West R	1							110	343		110							28	61.7		11.8
Antigonish	2	24.6		268.1		238.0	195.5	182.7	256.9	123.4	201.3	24.6		86.6		145.0	126.8	179.2	173.6	93.2	83.4
	3							62.1	83.6	90.2	35.2							20.5	8.4	17.1	11.2
	4	71.8	226.4	244.8	165.0	275.0	237.2	207.7	545.1	185.5	169.1	52.5	67.7	78.2	51.0	71.0	78.6	95.8	182.3	63.6	61.7
	5							113.0		129.0	116.1							42.8		28	29
Pomquet	6			3.2		0.0		8.4						20.5		13.0		1.8			

* no estimate possible

** named site 6 in 1978

*** named site 4 in 1978

a Site 8 was electrofished in 1999 to replace site 6 which could not be fished due to windfalls creating a deep pool throughout the site. Site 8 was about 2 km upstream of site 6 but in similar habitat.

Table 8. Results of Northumberland Shore mainland Nova Scotia rivers electrofishing,1992-1999.
Data for 1992-1994 from Claytor et al. (1995) and Chaput and Jones (1994)

		Fry caught (5 minutes)								Parr caught (5 minutes)							
River	Site	1992	1993	1994	1995	1996	1997	1998	1999	1992	1993	1994	1995	1996	1997	1998	1999
River Philip	1																
	2				7			0	20				1			10	1
	3				104								20				
	4																
	5		4								3						
	6		90								33						
Wallace	1		14		26	31		6	15		10		12	12		6	5
	2		11		50						3		2				
	3		37		26	48	93		13		31		17	5	18		0
	4		24		16	14		0	11		26		11	12		11	3
	5		25		16	12			18		14		6	20			6
River John	1		0		7						27		25				
	2		11		0			0			34		48			21	
	3		54		73						27		13				
	4		35		16			13			10		21			14	
	5		17		14			0			9		15			6	
	6		9		21			2			11		9			13	
Middle River, Pic	95				0								3	6			
(all sites fished 1	95				0	3							3	7			
except 96.5 fishe	95				0								0	4			
15 min.)	95				0	0							0	0			
	97													5			
East River, Pictou	5	36	65	53	45		68	21	48	10	18	23	16		29	11	7
	6	16		22	0				0	0		0	13				0
	7	51		70	57			43	43	45		26	45			31	35
	8		57								41						
Sutherlands	1	37		51	32	30			49	28		42	24	28			31
	2	0			0				0	0			0				0
	3	91		100	61	42			59	17		27	12	19			7
French, Pictou	1	56		28						45		23					
	2	29		69					55	3		8					7
	3								8								6
Barneys	1	46		94					16	42		66					8
	2	44					10		11	11					15		9
	3						24								17		
	4	13		30						2		8					
West River, Antigonish			87								33						
South River	1						75		17						0		0
	2						116		57						4		20
	3						188		14						61		14
Pomquet	1	36		64			14		6	3		6			9		14
	2	75		66						30		6					
	3	35		78						15		30					
	4	49		15			84		27	32		19			22		12
	5	36		36			59		13	37		23			38		16
Afton	1	0		0			0		0	0		0			0		0
	2	20		78			62			16		28			39		
	2a								1								8
	3	43		64						3		21					
Tracadie	1						3								11		
	2						97								31		
	3						26								25		

Table 9a. Areas covered during the mark-and-recapture survey of River Philip and number of fish marked and observed by snorkel-divers in 1999.

Marks (tags) applied Oct. 28 Snorkel-diver survey Nov. 2/99

Sections	Marks applied	Diver survey (captures)		Recaptures
		Large salmon	Grilse	
Section A: Thompson Road bridge to Williamsdale	0	30	16	0
Section B: Williamsdale to Forks pool Collingwood	4	27	19	1
Section C: Collingwood to first wooden bridge	4	48	12	1
Section D: First wooden bridge to second wooden brid	1	24	11	3
Section E: Second wooden bridge to Spencer's Bridge	4	43	13	2
Total	13	172	71	7

Table 9b. Mark-recapture data and estimates of adult Atlantic salmon returns to River Philip in 1999.

Adult salmon population estimate for the area above Spencer's Bridge

Marks applied = 13
Captures = 172
Recaptures = 7

	Petersen (corrected)			Bayesian		
	Estimate	95% C.I.		Estimate	90% C.I.	
Post-fishery estimate	302	156.3 -	636	320	200 -	830
Retained grilse	101			101		
5% hook-and-release mortality[1]	16.9			16.9		
Pre-fishery estimate	420	274.2	754	437.9	317.9	948

Total population estimate as follows:

Large salmon above Spencer's Bridge	320			
Grilse:large salmon ratio in diver survey	71	:	172 =	0.4 :1
Estimate of grilse above Spenser's Bridge	132			
Population estimate for river above Spencer's Bridge	452			

Area above Spencer's Bridge is 63.25% of the watershed.

Total post-fishery population estimate for River Philip for 1999 (452/0.6325) =	**715**	**grilse and large salmon**
Number of grilse in post-fishery population for 1999	209	
Number of large salmon in post fishery population for 1999	506	
Pre-fishery population estimate	864	
Pre-fishery large salmon population	538	
Pre-fishery grilse population	326	

1999 capture rate:

Total preliminary catch =	439
Capture rate	0.53
Large salmon capture rate (293/(538-17))	0.56
Grilse catch rate (146/(326-14))	0.47

1 Fish enter rivers during colder autumn period so hook-and-release mortality is assumed to be 5%.

Table 10 . Atlantic salmon spawner requirements (habitat areas, eggs, and adults), and preliminary returns, escapements and returns relative to conservation requirements (surplus or deficit) for Northumberland Strait, Nova Scotia, rivers in 1999[a].

River	Habitat area (m^2*10^2)	Requirements: Eggs x 10^3	Requirements: Spawners Grilse	Requirements: Spawners Salmon	Preliminary catch 1999: Preliminary angling catch: Total grilse	Preliminary angling catch: Salmon	Preliminary angling catch: Grilse retained	First Peoples' harvest[b]: Grilse	First Peoples' harvest[b]: Salmon		Estimated returns to the estuary: Grilse	Estimated returns to the estuary: Salmon	Estimated escapement: Grilse	Estimated escapement: Salmon	Capture rates[c]: Grilse	Capture rates[c]: Salmon	Surplus or deficit[d]: Grilse	Surplus or deficit[d]: Salmon
Afton	189	45	0	14	0	0	0				N/A	N/A					N/A	N/A
Barney's	2,128	511	17	79	0	9	0	0	13		N/A	N/A					N/A	N/A
East River, Pictou	7,291	1,750	57	271	58	217	22	11	39	g	135	425	100	375	(0.47)	(0.56)	43	104
French, Colchester	2,804	673	22	104	0	0	0				N/A	N/A						
French, Pictou	1,740	417	14	65	0	0	0	0	13		N/A	N/A						
Middle, Pictou	2,953	709	23	110	0	0	0				N/A	N/A						
Pomquet	769	185	1	57	7	2	2				N/A	N/A						
Pugwash	2,470	593	19	92	0	0	0				N/A	N/A						
River John	3,973	954	31	148	22	60	18	0			47	107	29	104	(0.47)	(0.56)	-2	-44
River Philip	9,621	2,309	75	358	146	293	101	14	17		326	538	209	506	0.47	0.56	134	148
South	950	228	0	70	31	43	16				N/A	N/A						
Sutherlands[f]	666	160	5	25	0	0	0	0	14		25	28	20	26			15	1
Tracadie (Monastery)	526	126	1	39	0	0	0				N/A	N/A						
Wallace River	6,229	1,495	49	232	22	101	11				47	179	36	174	(0.47)	(0.56)	-13	-57
Waugh	3,132	752	25	116	20	27	13				43	48	29	47	(0.47)	(0.56)	4	-70
West River, Antigonish	4,803	1,153	1	353	186	231	81				398	410	312	399	(0.47)	(0.56)	311	46
West River, Pictou	3,326	798	26	124	83	113	40				178	201	135	195	(0.47)	(0.56)	109	71
Totals	53,570				575	1096	304											

a No catch was reported so returns and escapements could not be calculated for Afton; Barney's; French, Colchester; French, Pictou; Middle, Pictou; Pomquet; Pugwash; South, and Tracadie (Monastery) rivers.

b First Peoples' harvest on East River and River Philip that occurred in trap nets took place in the estuary below any angling fishery. Estuary harvest values were included in the returns estimates. Merrigomish harvest quota (reported to have been taken as a minimum) was divided between Sutherlands, Barney's and French rivers.

c Capture rate calculated from a mark-and-recapture population estimate and reported angling catch on River Philip;

d Surplus large salmon may preclude the need for any grilse as all eggs are expected to come from large salmon; grilse spawners are only required to provide males to ensure a 1:1 ratio of males to females.

f Escapement for Sutherlands River was based on a snorkel-diver survey.

g First Nation harvest numbers are guestimates and prorated into large and small based on angler data or float count. Note that some prior data was available but no final catch estimate.

Table 11. Number of fish observed during the annual survey of the Sutherlands River by snorkel divers, 1995 to 1999, and the average escapement.

Conservation requirement:		25	large salmon
		5	grilse

Year	Date surveyed	Number of fish	
		Salmon	Grilse
1995	6-Nov	24	17
1996	7-Nov	48	15
1997	17-Nov	46	25
1998	9-Nov	26	20
1999	3-Nov	28	25
Average		34.4	20.4
Average relative to requirement		138%	408%
Standard deviation of average		11.61	4.56
90% C.L of average		11.07	4.35

Table 12. Estimates of returns, escapements and percentage of conservation requirements achieved with five year (1994-98) means for East River, Pictou; River Philip; and West River, Antigonish. Estimates for 1992-1994 are revised from Claytor et al. (1995) to reflect changes in habitat areas; the 1995 figures are from O'Neil et al. (1996); and the 1996-99 figures are based on mark-recapture experiment population estimates or capture rates.

	Grilse				Large salmon			
	Returns		Escapement		Returns		Escapement	
Year	Number	% of requirement	Number	% of requirement	Number	% of requirement	Number	% of requirement
East River, Pictou								
1992	251	440 %	184	323 %	523	193 %	519	192 %
1993	127	223 %	92	161 %	456	168 %	313	115 %
1994	60	105 %	41	72 %	265	98 %	123	45 %
1995 [a]	152	267 %	127	223 %	141	52 %	111	41 %
1996 [a,b]	105	184 %	61	107 %	592	218 %	529	195 %
1997	97	170 %	75	132 %	484	179 %	441	163 %
1998	81	142 %	52	91 %	248	92 %	241	89 %
1999	135	237 %	100	175 %	425	157 %	375	138 %
Mean 1995-1999	114	200 %			378	139 %		
sdev	28.9299	27.5834568 <=90%CL(mean)		sdev	181.87	173.407764 <=90%CL(mean)		
River Philip								
1992	398	531 %	292	389 %	461	129 %	457	128 %
1993	373	497 %	276	368 %	474	132 %	469	131 %
1994	198	264 %	137	183 %	281	78 %	264	74 %
1995 [a]	568	757 %	430	573 %	572	160 %	508	142 %
1996	269	359 %	94	125 %	1076	301 %	1046	292 %
1997	188	251 %	131	175 %	640	179 %	613	171 %
1998	153	204 %	72	96 %	350	98 %	333	93 %
1999	326	435 %	209	279 %	538	150 %	506	141 %
Mean 1995-1999	301	401 %			635	177 %		
sdev=	164.02	156.386814 <=90%CL(mean)		sdev	268.84	256.332019 <=90%CL(mean)		
West River, Antigonish								
1992	312	[c]	233	[c]	398	113 %	395	112 %
1993	148	[c]	108	[c]	339	96 %	335	95 %
1994	105	[c]	77	[c]	181	51 %	180	51 %
1995	315	[c]	268	[c]	307	87 %	300	85 %
1996	505	[c]	379	[c]	832	236 %	807	229 %
1997	153	[c]	130	[c]	576	163 %	571	162 %
1998	206	[c]	135	[c]	344	97 %	334	95 %
1999	398	[c]	312	[c]	410	116 %	399	113 %
Mean 1995-1999	315	[c]			494	140 %		
sdev	142.402	135.774424 <=90%CL(mean)		sdev	215.34	205.322116 <=90%CL(mean)		

Conservation requirements:	Grilse	Large salmon
East River, Pictou	57	271
River Philip	75	358
West River, Antigonish	1	353

a The 1995 return estimate includes First Nation catches on East River and River Philip. The 1996 return estimate includes First Nation catches on East River only.

b The 1996 return estimate is based on the mean population estimate.

c The number required is only 1 grilse so percent surplus not applicable. Number surplus can be calculated by subtracting 1 from the number that escaped.

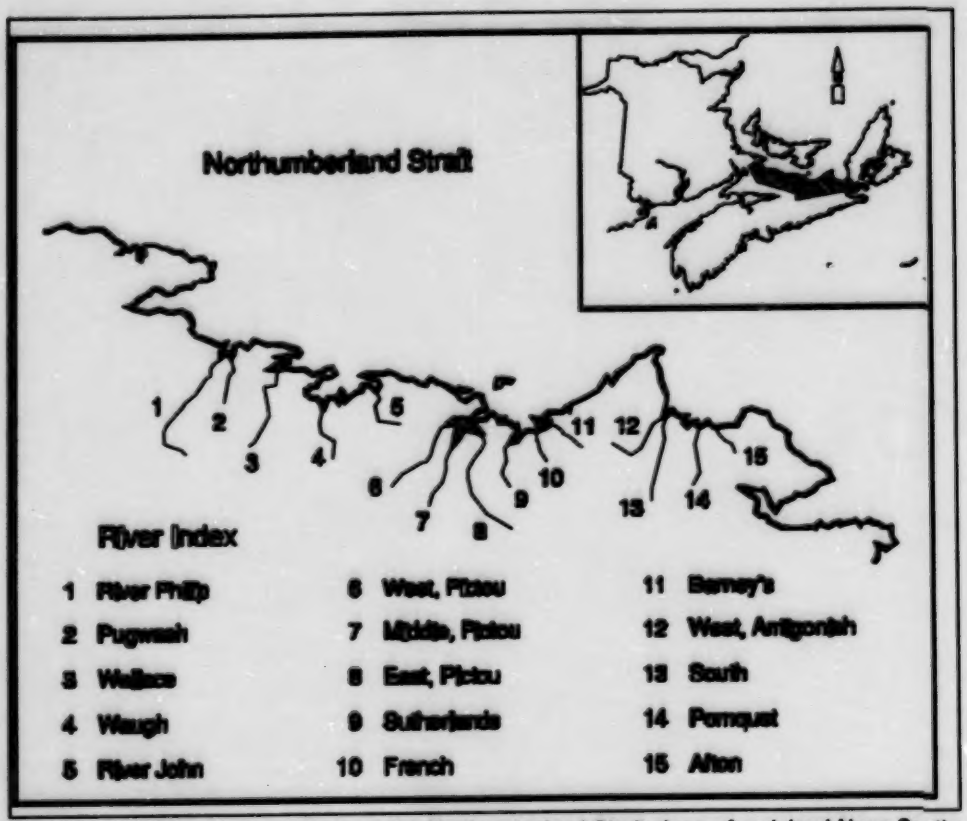


Figure 1. Location of salmon rivers on the Northumberland Strait shore of mainland Nova Scotia.

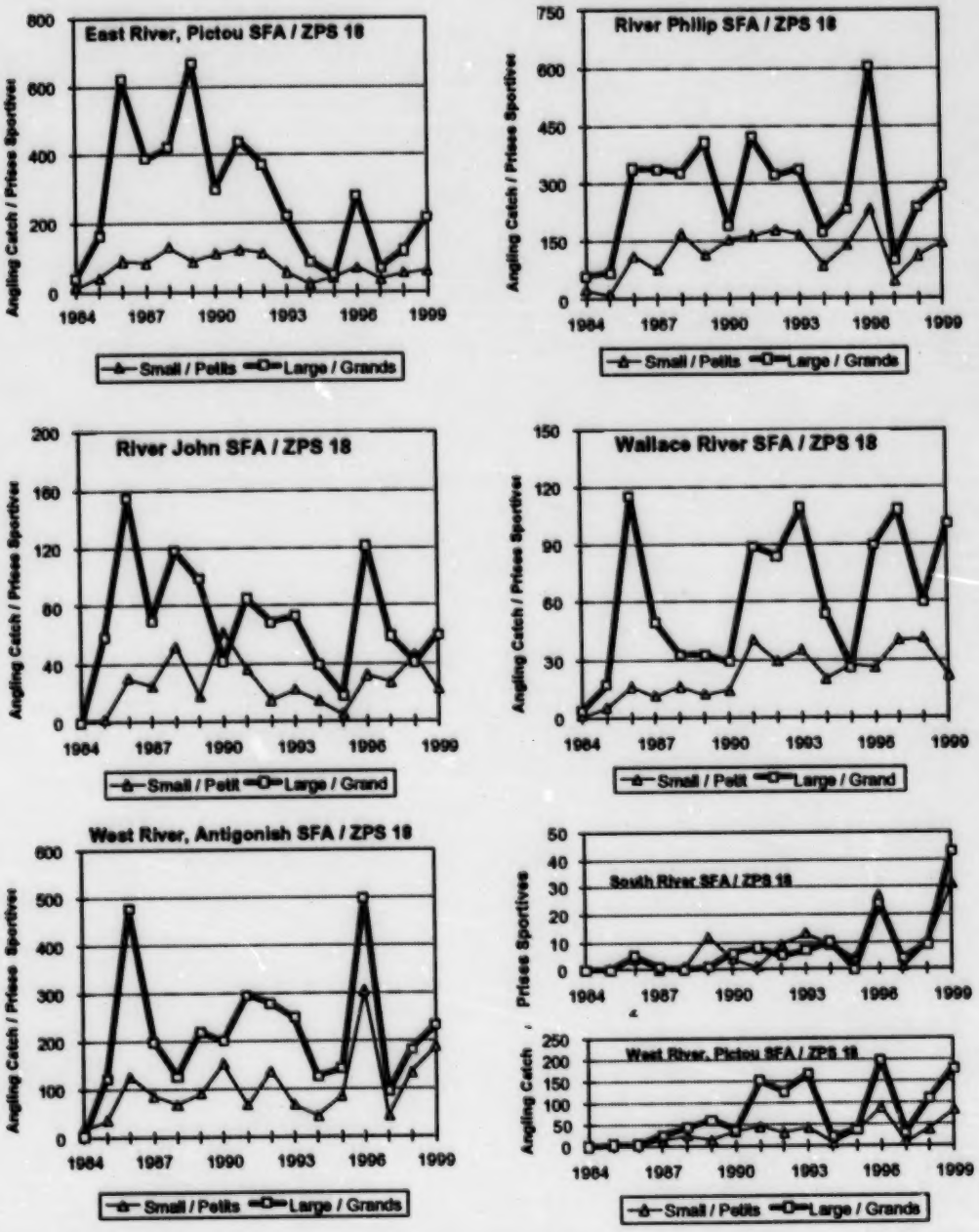


Figure 2. Catch of large and small salmon on several Northumberland Strait area of Nova Scotia, rivers, 1984-99.

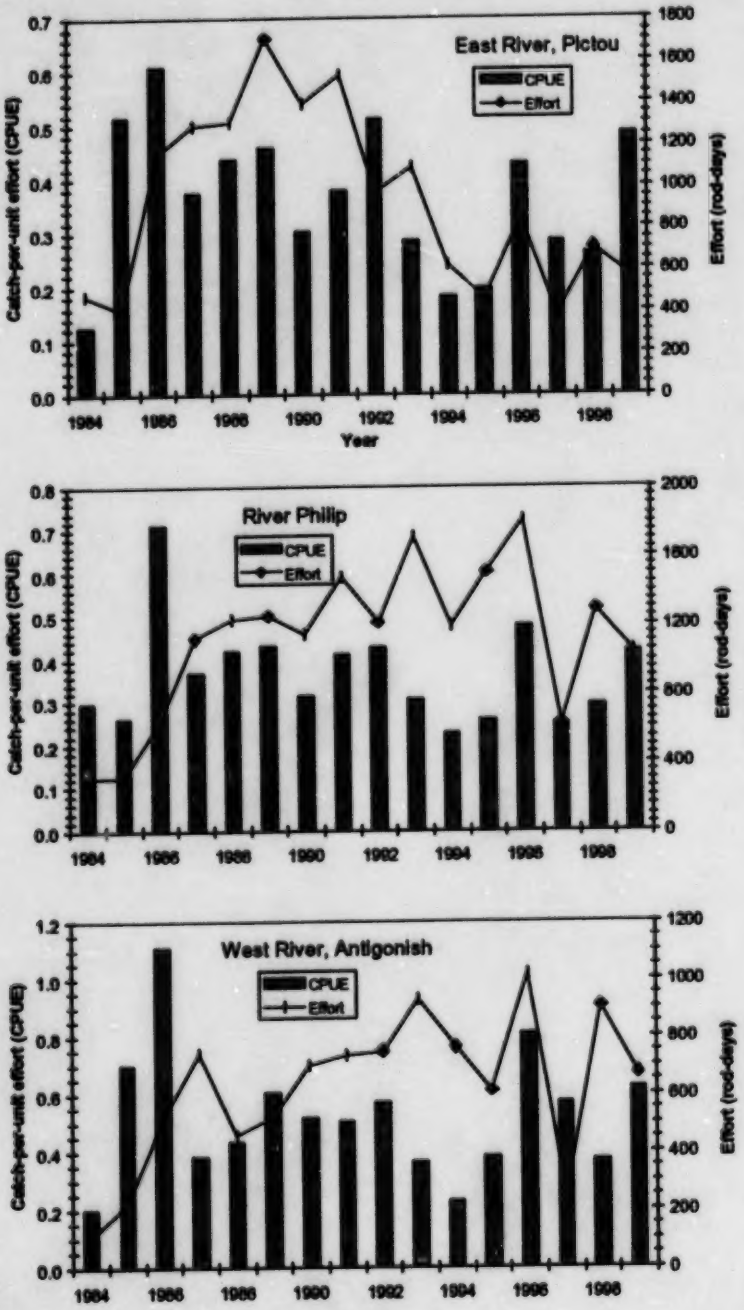


Figure 3. Catch-per-unit effort and effort from license stub data for three rivers in the Northumberland Strait, Nova Scotia, area, 1984-1999.

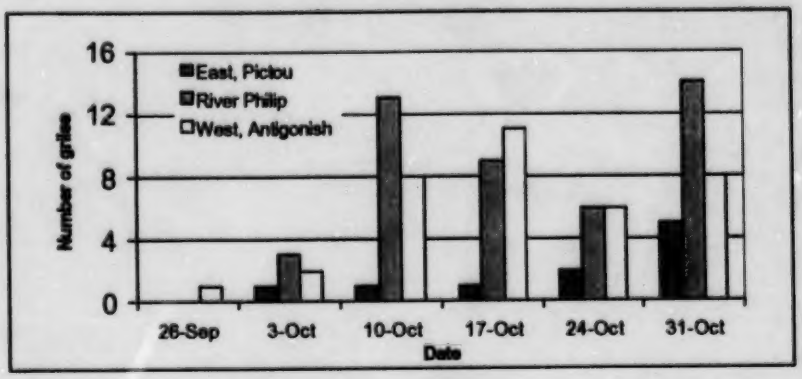
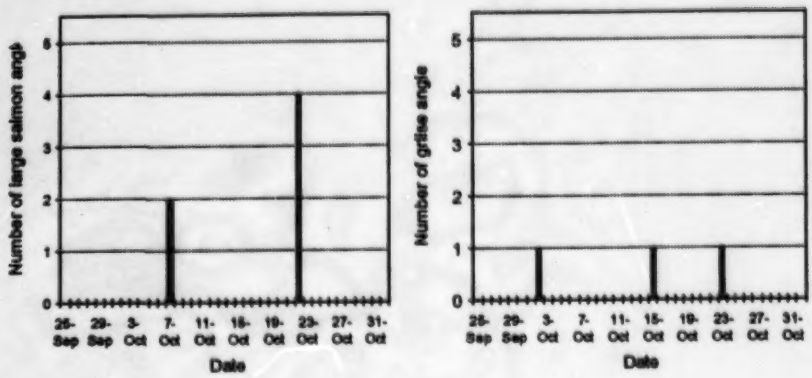
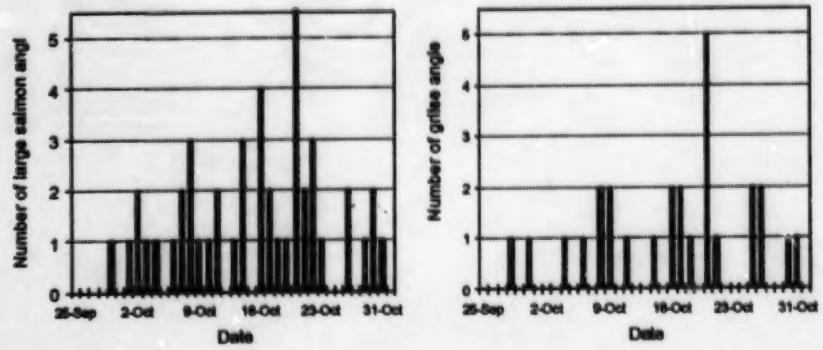


Figure 4 . Number of grilse angled by week on the three key rivers on the Northumberland Shore of Nova Scotia, as reported on license stubs.

East River (Pictou)



River Philip



West River (Antigonish)

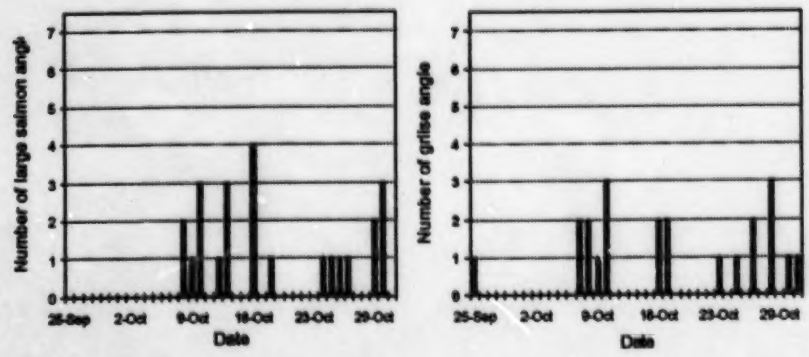


Figure 5. Run timing of large salmon and grilse based on catch reports by date from logbooks on West River Antigonish , East River Pictou and River Philip 1999.

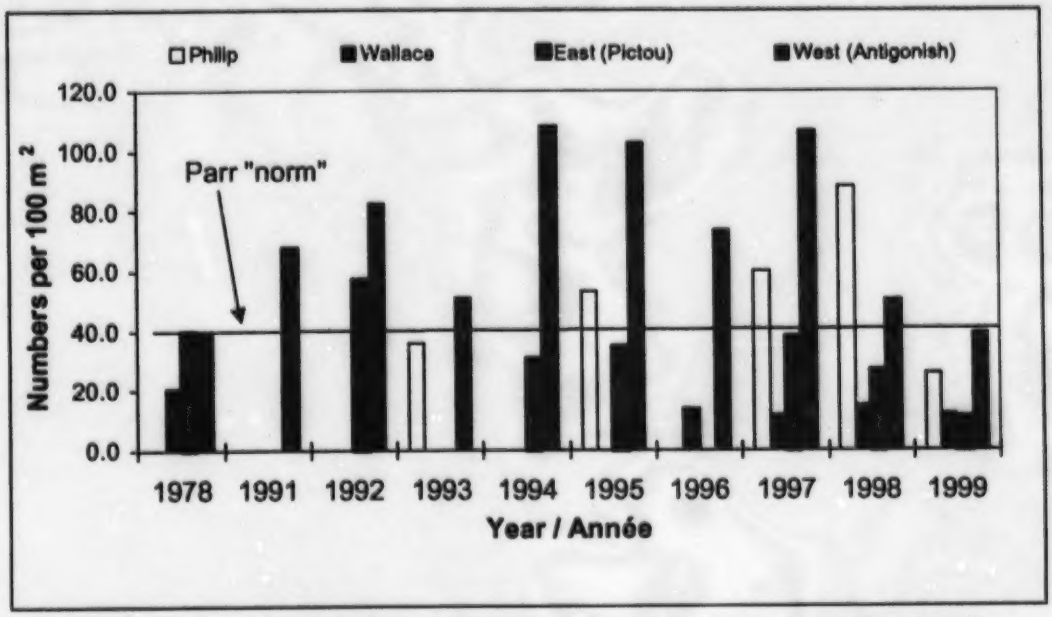


Figure 6. Total parr density on several Northumberland Strait, Nova Scotia area, rivers in 1978 and during the years 1991-1999. The "Elson norm" line is indicated. For the purposes of comparison, parr densities may include from one to five sites and where more than one site is involved, densities are averaged.

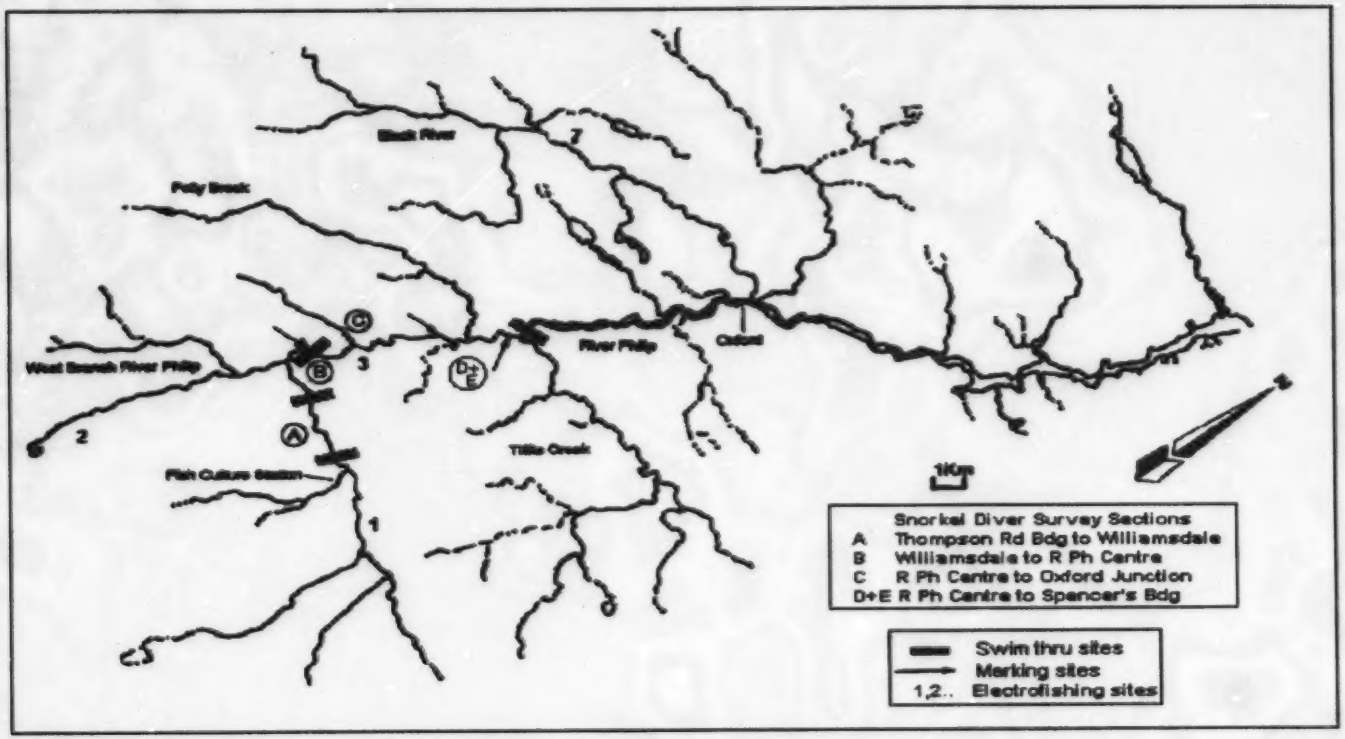


Figure 7. Atlantic salmon marking sites and snorkel diver survey sections covered during the mark-and-recapture experiment to estimate the adult salmon population on River Philip in 1999.

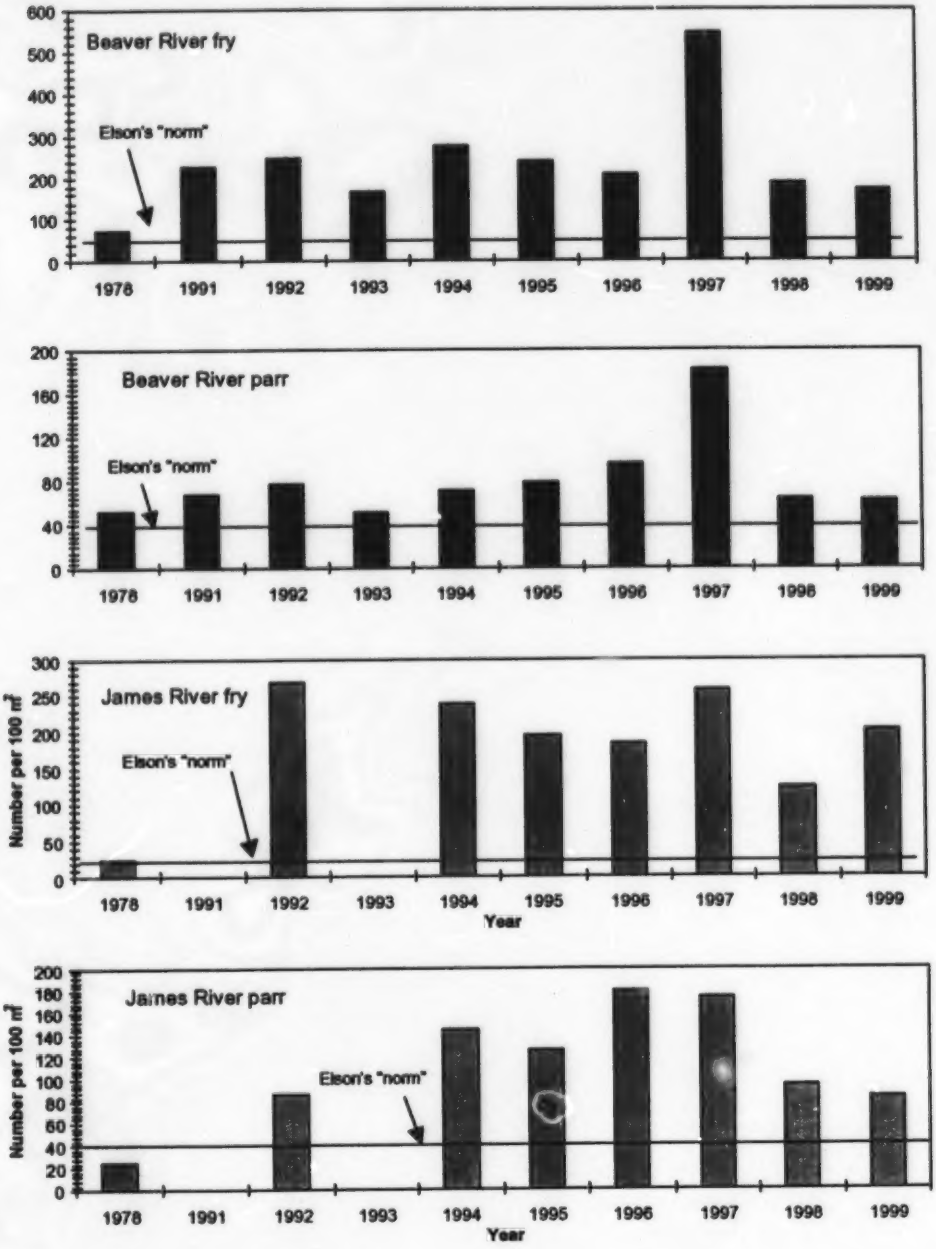


Figure 8. Densities of juvenile Atlantic salmon caught by electrofishing at two sites on West River, Antigonish, at Beaver River (site 4) and at James River (site 2), in 1978 and from 1991 to 1999. Not all sites were done in all years (see Table 7). Habitat improvements were completed at the James River site during 1989 and 1990.

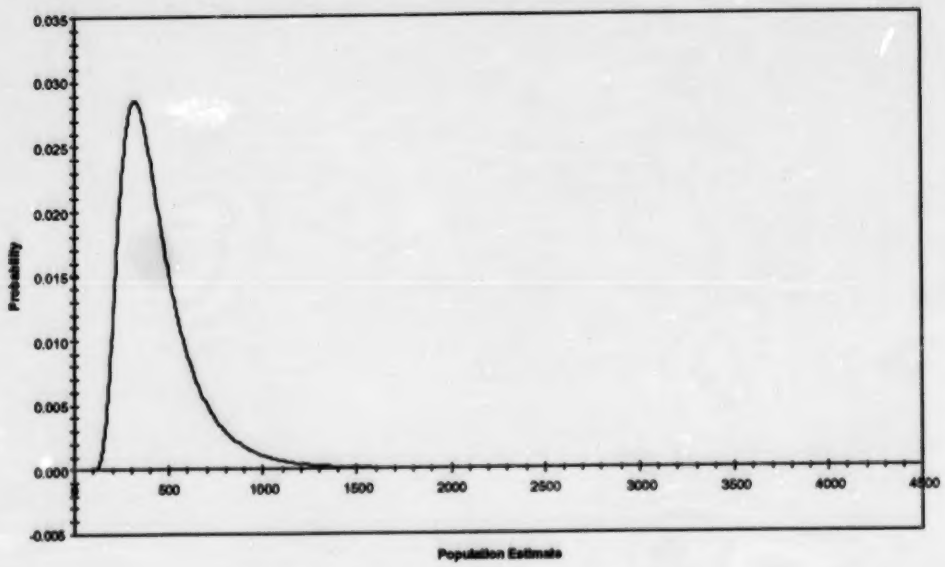


Figure 9. Probability distribution of the post-fishery population estimates of Atlantic salmon for the 1999 mark-recapture experiment used to estimate the River Philip salmon population in the area of the river above Spencer's Bridge.

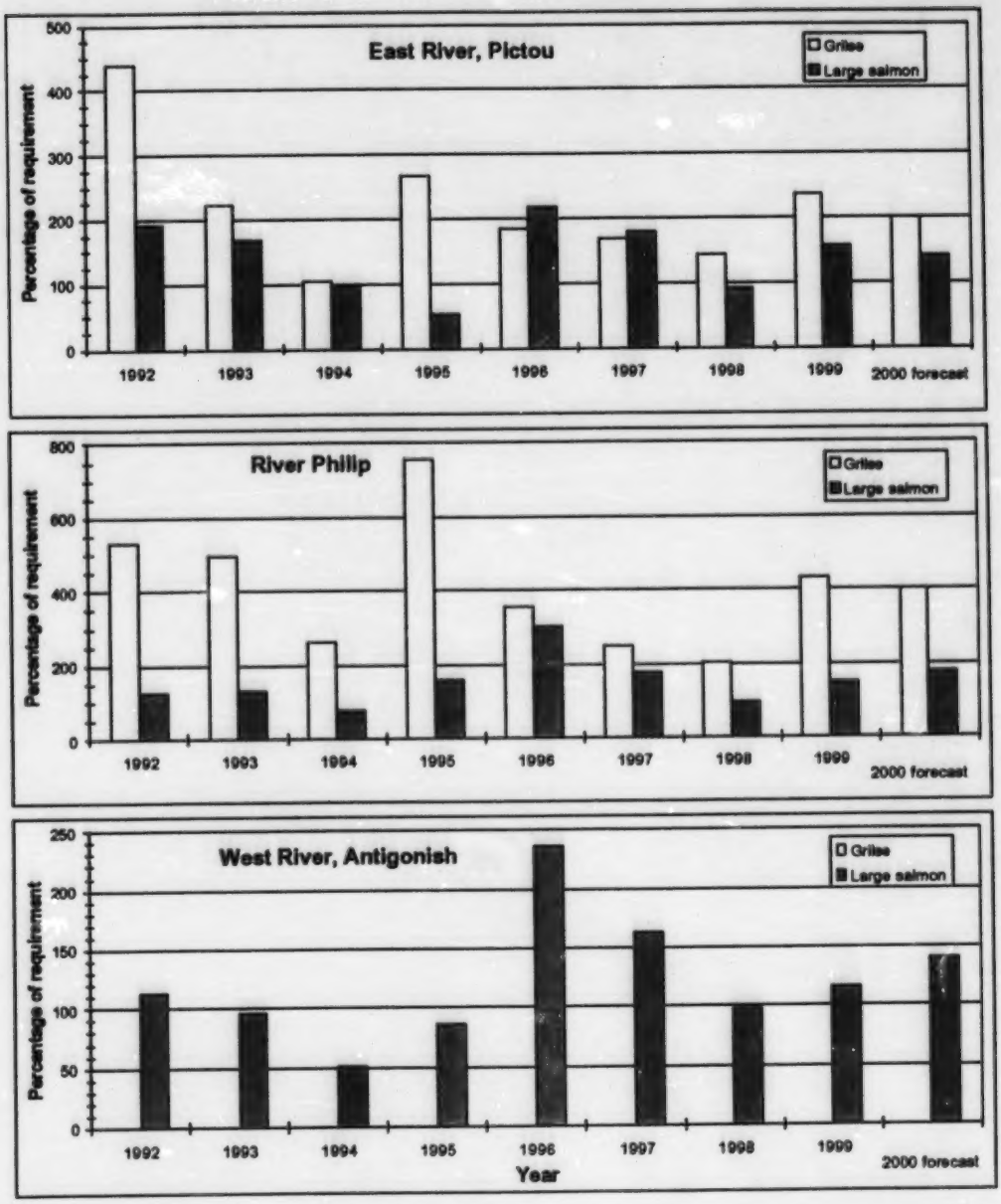


Figure 10. Percentage of conservation requirement achieved by returns and escapements (dark lines on bars) on three Northumberland Strait, Nova Scotia, area rivers, 1992-1998, and the 1999 forecast based on the mean of 1994-98 values. The escapements for the years 1992-94 were estimated with adjusted sportcatches and a range of exploitation rates; for 1995, the catch data were not adjusted and the exploitation rate was calculated from the 1995 Margaree River data; the 1996 figures and beyond are based on mark-recapture population estimates and capture rates.

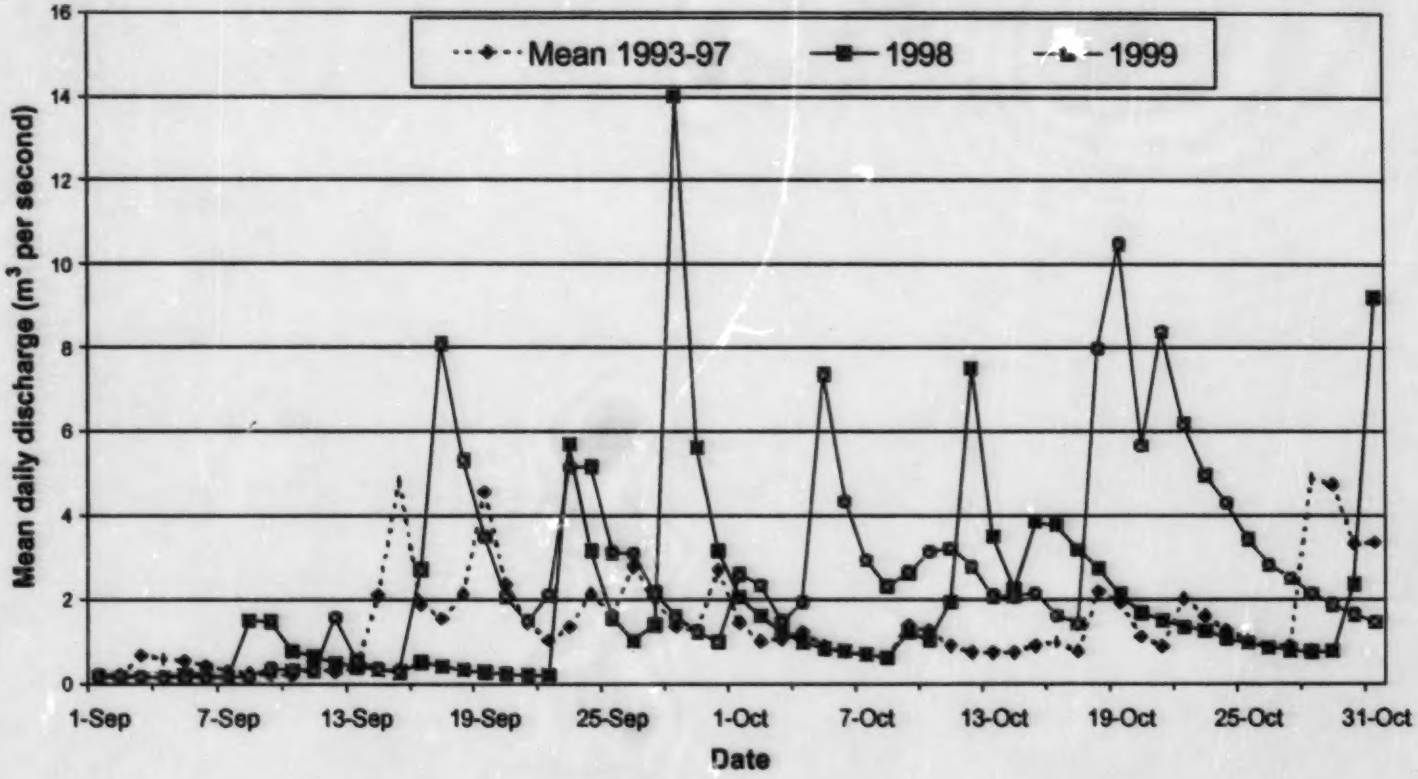


Figure 11. Mean daily discharge for Middle River, Pictou, at Rocklin, with the mean for 1993-97 and daily values for 1998 and 1999.

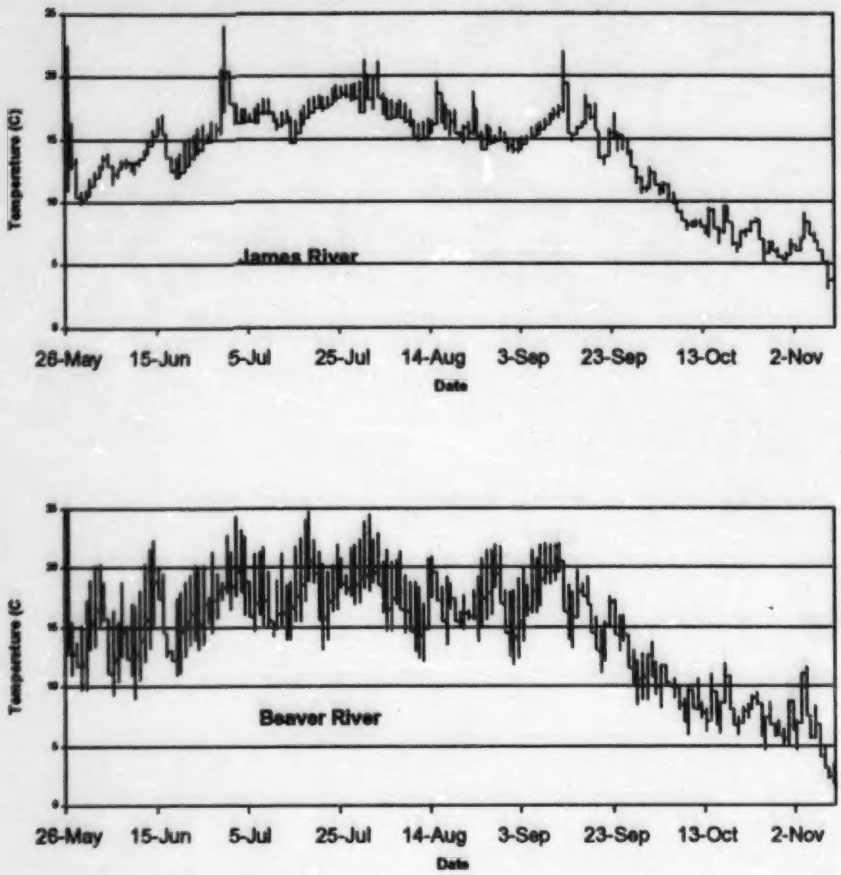


Figure 12. Water temperatures as recorded at 30 minute intervals on two tributaries of West River, Antigonish, Beaver and James rivers, in 1999.